Three-dimensional modeling of the solar wind: From the coronal base to the outer heliosphere

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We have developed a global fully three-dimensional magnetohydrodynamic solar wind model for the region that extends from the coronal base to 100 AU. The simulation domain consists of tree spherical shell subdomains with computational boundaries between them placed at 20 solar radii and 0.3 AU. The location of the first boundary ensures that the flow at the boundary is both supersonic and super-Alfvénic. A steady-state solution in the innermost (coronal) region is obtained by the time-relaxation method. The solution uses a tilted dipole model or solar magnetograms as the boundary condition at the coronal base and includes a flux of Alfvén waves in the WKB approximation which provide additional acceleration for the coronal outflow in the open field regions. The intermediate region solution is constructed by the integration of steady-state equations along radius using a marching scheme. The outer region solution (0.3-100 AU) is obtained again by the time relaxation and takes into account turbulence transport and heating as well as heating, flow deceleration, and other effects due to the interstellar pickup protons treated as a separate fluid. We use the model to simulate the global steady-state structure of the solar wind from the coronal base to the heliospheric boundary and compare the results with Ulysses and Voyager observations.